

Title Page

1. Title: Extra-ocular movement restriction and diplopia following orbital fracture repair

2. Authors: H.A. Shah, MD¹, Taha Shipchandler, MD³, Dominic Vernon, MD³, Maraya Baumanis³, David Chan, MD³, William R. Nunery, MD FACS², Hui Bae Harold Lee MD FACS²

3. Affiliations: ¹Pediatric Ophthalmology and Adult Strabismus, Illinois Eye and Ear Infirmary, University of Illinois at Chicago ²Oculofacial Plastics and Orbital Surgery, Indianapolis, Indiana and Louisville, Kentucky ³Otolaryngology and Head and Neck Surgery, Indiana University School of Medicine

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8. Corresponding author:

Taha Shipchandler MD, FACS

Department of Otolaryngology-Head & Neck Surgery

Fesler Hall

1130 W. Michigan Street, Room 455

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Indianapolis, IN 46202
317.278.1258
317.274.8285(fax)
tshipchandler@hotmail.com

9. First author: Hassan A. Shah,MD

10. Order of authors: H.A. Shah, MD¹, Taha Shipchandler, MD³, Dominic Vernon, MD³, Maraya Baumanis³, David Chan, MD³, William R. Nunery, MD FACS², Hui Bae Harold Lee MD FACS²

Abstract

Purpose: To report a series of patients with extra-ocular movement restriction and diplopia after orbital fracture repair, and determine the effect of timing of repair and the type of implant used.

Methods: A chart review was conducted identifying all patients >18 years of age at our institution between June 2005 and June 2008 who underwent orbital fracture repair, and presented with clinically significant diplopia and extra-ocular movement restriction persisting longer than one month after repair. Data collected included timing of repair, implant used within the orbit, and need for revision.

Results: Ten patients were identified with a mean time to primary orbital fracture repair at 9 days (range 1- 48). Seven patients underwent revision of their orbital fracture repair with removal of the previously placed implant and replacement with non-porous 0.4 mm Supramid Foil, whereas one patient underwent lateral and inferior rectus recessions without revision of primary fracture repair. Titanium mesh was the intra-orbital implant found in all patients requiring revision of orbital fracture repair. All revisions resulted in resolution of clinically significant diplopia.

Conclusions: Clinically significant diplopia and extra-ocular movement restriction is not an uncommon complication after orbital fracture repair. In our series, there was a strong association between these complications and the use of porous titanium mesh implants.

Revision of fractures significantly improved diplopia in all but one patient. This suggests that meticulous fracture repair and the use of non-porous implants primarily or secondarily may preclude the need for strabismus surgery after orbital trauma.

ACCEPTED MANUSCRIPT

I. Introduction

Blunt force orbital trauma is a common occurrence. Despite the frequent nature of these injuries, no criterion standard exists regarding timing of repair, technique of repair, and optimal implant. For example, recommendations regarding timing of surgical repair of orbital fractures have ranged from observing for 4 to 6 months before surgery^[1], to performing early repair within 2^[2-5]. The choice of alloplastic material used within the orbit is also controversial. Widely used porous materials include titanium mesh and porous polyethylene where as non-porous materials include nylon foil and silicone. All materials have had problems reported including cicatrization, extrusion, infection, and bleeding.

A wide range of outcomes after surgical repair of orbital fractures has been reported regarding diplopia, arguably the most important complication of orbital trauma. Persistent diplopia after surgical repair of combined orbital floor and medial wall fractures is reported to be as high as 76% by Biesman et al^[6]. In our study, there were no cases of diplopia found when surgical repair on the same combination of fractures was performed in ideal circumstances (primary repair within 5 to 21 days)^[7].

The purpose of this study was to report a series of patients presenting with persistent diplopia after orbital fracture repair and to determine any association with timing of repair or the type of implant used within the orbit.

II. Methods

A retrospective review was conducted identifying all patients greater than 18 years of age at our institution between June 2005 and June 2008 who underwent orbital fracture repair and who presented with clinically significant diplopia and extra-ocular movement restriction persisting longer than one month after repair. Clinically significant diplopia was defined as diplopia within 30 degrees of primary gaze in any direction. Data collected included fracture site, timing of repair, implant used within the orbit, need for revision, and type of revision performed.

All data accumulation was carried out according to the guidelines of the Institutional Review Board (IRB) of the University of Louisville.

III. Results

Ten patients were identified who presented to the Oculoplastics Clinic at the University of Louisville with clinically significant diplopia lasting longer than one month after orbital fracture repair. All patients were repaired by the various facial surgery services at the institution.

Mean time to primary orbital fracture repair was 9 days (range 1- 48). Nine of 10 patients were repaired within two weeks of injury whereas only one patient was repaired after this.

Nine out of 10 patients had fractures involving combined medial wall and orbital floor fractures.

Seven out of 10 patients were found to have titanium mesh as the intra-orbital implant used for primary repair. All seven patients underwent revision of their orbital fracture repair with removal of the previously placed titanium implant and replacement with non-porous 0.4 mm Supramid Foil. All of these revisions resulted in resolution of clinically significant diplopia. However, only two of seven patients were able to recover full extraocular movements while five of seven patients had mild residual restriction.

One patient was found to have non-porous Supramid foil. Although this patient had diplopia within 30 degrees of primary gaze in left gaze and minus 2 abduction of the left eye, he chose to forego any further reconstructive surgery.

We could not identify the type of intra-orbital implant from operative notes in two of ten patients. One of these patients underwent lateral and inferior rectus recessions without revision of primary fracture repair, which resulted in resolution of clinically significant diplopia but with residual mild restriction in upgaze. The other patient with unknown intra-orbital implant chose to forego further surgery.

Titanium mesh was the intra-orbital implant found in all patients requiring revision of orbital fracture repair. By contrast, only one patient presenting with persistent diplopia had undergone primary repair using non-porous Supramid Foil. All revisions resulted in resolution of clinically significant diplopia, however, six out of eight patients who

underwent surgical revision including strabismus surgery had residual restriction of extra ocular motility despite resolution of clinically significant diplopia.

IV. Discussion

Clinically significant diplopia and extra-ocular movement restriction is not an uncommon complication after orbital fracture repair despite improvements in surgical technique and the introduction of newer alloplastic materials over the years. In our series, there was a very strong association between clinically significant diplopia and the use of porous titanium mesh implants. In fact, 70% of the patients who presented to our clinic with persistent diplopia after orbital fracture repair were found to have titanium mesh as the intraorbital material used for orbital fracture repair.

Diplopia after orbital fracture repair has been attributed to a variety of causes including direct damage to the muscles or nerves, persistent entrapment of orbital tissue within the fracture site, and cicatrization of tissue surrounding the implant used for repair. Pre-operative factors reported in the past that predispose to post-operative diplopia have included combined orbital floor and medial wall fractures^[6], fractures involving more than half the orbital floor^[5] and those patients with CT evidence of entrapped muscles^[8]. However, recent studies have reported excellent results in regards to post-operative diplopia despite the presence of these factors using porous polyethylene^[9-10], 0.3 mm thick titanium^[11] and nylon foil^[7, 12]. These studies provide evidence that for most orbital fractures, post operative diplopia can be avoided as long

as repair is performed in a meticulous fashion and the right material is used within the orbit. This also suggests that post-operative diplopia can be corrected or improved by revisiting the fracture site as opposed to performing strabismus surgery as the primary means of correcting diplopia in this setting.

Titanium mesh has been cited as being an excellent alloplastic material for use within the orbit as it has a low rate of extrusion and infection^[13-16], which has been attributed to the tendency of titanium to cause an inflammatory and fibrogenic response to the surrounding tissue. Titanium has been shown to cause increased levels of fibroblast activity especially around grooves and ridges^[17-18], as well as increased levels of transforming growth factor- β and platelet derived growth factor^[19]. Although these properties may provide the benefit of improved bio-integration resulting in decreased extrusion rates and infection, the fibrotic response to titanium is undoubtedly detrimental within the orbit where scarring and cicatrization may cause extra-ocular movement restriction resulting in diplopia.

We previously reported ten patients with orbital adherence syndrome secondary to titanium implant material resulting in extra-ocular movement restriction in nine out of the ten patients^[20]. In that series, six out of nine patients underwent removal of titanium hardware and replacement with 0.4 mm non-porous nylon foil (Supramid) resulting in improvement in diplopia and extra-ocular motility. In all cases, extensive fibrosis was found connecting the surrounding orbital tissue to the despite proper placement of the titanium implant over the orbital floor. Although that case series was reported to define orbital adherence syndrome secondary to titanium implants, our current series looked at

all patients presenting with persistent diplopia after orbital fracture repair regardless of material used within the orbit. It is notable that the percentage of patients in our series with titanium mesh within the orbit is exceedingly high (70%).

We believe that this series provides further evidence that orbital adherence syndrome is an important complication of titanium mesh implants within the orbit as this was the common factor found in a significant percentage of all patients presenting to our clinic with clinically significant diplopia and extra-ocular movement restriction. A non-porous implant such as 0.4 mm thick nylon foil (Supramid) provides a better material as it is not prone to the fibrogenic response that titanium elicits. Also, no complications such as bleeding in the capsule, extrusion, or infection were reported using nylon foil of this thickness in our previous series of orbital fracture repair of 102 patients ^[7].

Despite revision of fractures and improvement of diplopia in all patients undergoing secondary orbital repair and removal of titanium mesh, residual extra-ocular motility restriction was still present in six of seven patients. The one patient who underwent strabismus surgery also had remaining extra-ocular movement restriction.

These data underline two very important points. Firstly, the importance of meticulous repair of orbital fractures in the primary setting cannot be stressed enough. Revision of fractures may improve diplopia but it is difficult to reinstate full motility with surgery in the late setting. Secondly, it is noteworthy that strabismus surgery was performed as a primary intervention in only one patient. This underlines the fact that diplopia in this setting should be approached with evaluation of the fracture site and possible revision before referral to a strabismus surgeon.

In conclusion, our study further stressed the relevance of orbital adherence syndrome associated with titanium implants, and provided evidence that revision of orbital fractures including removal of titanium orbital implants and replacement with non-porous implants can significantly improve diplopia. Also, meticulous fracture repair and the use of non-porous implants primarily or secondarily may preclude the need for strabismus surgery to correct diplopia after orbital trauma.

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